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AUTHOR Wells, Gordon; Chang-Wells, Gen Ling
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ABSTRACT

A discussion about the meaning of time that took place in a combined grade 3 and 4 classroom in Toronto, Ontario, Canada is described and analyzed. The paper begins by explaining how a failed classroom demonstration of a water clock resulted in an animated class discussion that led to the successful redesign of the clock. Next, recent work in sociocultural theory is reviewed as it applies to learning and teaching. After the school and classroom context are described, the discussion about the meaning of time is summarized and analyzed. The discussion was to serve as an occasion for the children and their teacher to make connections between the various activities in which they had engaged and the artifacts of various kinds that had mediated their practical study. It began with the teacher inviting the students to think about what they had learned during the preceding 5 weeks. The invitation led to discussions of the need for a standard, accurate measure of time; scientific processes; units of time; work with pendulums; sources of power for clocks; bases for units of time in the earth's movements; and time zones. Short excerpts from the discussion are presented. The role of teachers in the co-construction of knowledge is discussed next, followed by concluding comments about the themes and findings of the analysis. (AC)

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'WHAT HAVE YOU LEARNED?': CO-CONSTRUCTING THE MEANING OF TIME

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Gordon Wells
Ontario Institute for Studies in Education

Gen Ling Chang-Wells
Toronto Board of Education

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'WHAT HAVE YOU LEARNED?': CO-CONSTRUCTING THE MEANING OF TIME

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Have you ever tried making a water clock from pieces of wood left over from renovation, a plastic spoon, a yogurt carton and bits and pieces of string? At the suggestion of the teacher, I constructed such a device - with the help of the directions in a junior science guide - and took it to the combined Grade Three and Four class, in which the teacher and I were collaborating in a study of the Grade Three students as they worked on the theme of Time. When I finally got it set up, the teacher asked some of the children who had been watching me to demonstrate how it worked to the rest of the class. Unfortunately, it failed to work as expected. However, suggestions for fixing it were not slow in coming and soon an animated discussion was in full swing, as competing proposals were put forward, justified and evaluated. By the end of the day, some of the most enthusiastic engineers had succeeded in making it work.

I want to hold on to this event for a moment, and say a little more about its significance, as I perceive it. For it has come to function as an icon for me, as I have thought about the actuality of classroom activity from the perspective of its role in bringing the resources of the past to bear in equipping each new generation of students to meet the challenges of their future. As I shall try to show, this unplanned situation epitomized many of the characteristics of the transactional model of learning-and-teaching which we wish to explore through a more detailed examination of some of the episodes that we observed during the course of these students' study of time.

During the preceding weeks, the children we had been observing had engaged in a variety of activities designed to help them understand the need for a standard method of measuring time. They had also learned about some of the earliest timing devices by constructing simple versions for themselves and then using them to measure how long it took them to perform an activity such as walking round the room. The water clock, complete with its striking mechanism, was intended to add a further dimension to their study, by showing how the problem of marking the passage of time in a regular way could be solved by the use of a number of simple mechanical principles in combination. It was, one might say, a way of reconstructing the past with the intention that the children should grasp the principles involved in order to be able to use them in solving problems in the future.

However, as it transpired, my imperfect workmanship succeeded in teaching another lesson. For instead of serving merely as a demonstration of how the problem might have been solved in the past, the water clock became a problem in its own right. To it the children brought their own original and creative solutions, testing them in debate and subsequently in action, until they had created a functioning device that was better than the one I had originally constructed. And what they demonstrated in the process was that the most effective way to foster children's thinking and problem-solving ability is to present them with a challenge that engages their interest and invite them to create their own solutions. They certainly benefited from the experience, but the person who learned most from this incident was probably myself.

Before going on to look at further episodes from these children's study of time, therefore, I

should like to develop these ideas a little further by presenting a brief account of recent work in sociocultural theory, as it applies to learning and teaching in schools. For I believe the insights that it offers can help us to understand, and perhaps reinterpret, some of the most enduring characteristics of classroom practice.

Bringing the Past into the Future

Let me start with a quotation from Leontiev, who, with Vygotsky, is one of the founding fathers of sociocultural psychology. Describing the cultural continuity which makes human society uniquely different from that of all other species, he writes: 'a speci al form of transmitting the achievement of preceding generations to the next takes place in human society; that is the achievements are embodied in the material and spiritual products of human activities and specific human psychological abilities can be developed through the mastery of these products by each person' (1981, p.). And, more recently, Michael Cole makes a similar point: 'Human beings live in an environment transformed by the artifacts of prior generations .. the basic function [of which] is to coordinate [them] with the physical world and each other (1991, p.6).

Central to the thinking of this school, then, is the idea that the artifacts that were invented in the past to solve the problems that were encountered then can serve as a sort of external cultural memory, encoding the interactions of which they were previously a part and carrying their potential for solving similar problems into the present and the future. In order to benefit from this legacy, however, each new generation has to be inducted into the cultural practices in which they are used and be able to recognize when and how they are relevant.

But it is not simply to physical tools that these writers refer, nor to such social practices as marriage customs or legal procedures. More important is the recognition that language and the uses we make of it for remembering, reasoning, evaluating and so on, are also cultural artifacts and practices, and that these, too, have to be learned and mastered through social interaction in the context of joint activity. Thus all the higher mental functions, as Vygotsky (1978, 1981) called them, first exist and are encountered *inter-mentally*, in interactions between people; only when they are appropriated and internalized do they function *intra-mentally*, as a resource for individual thinking and problem-solving.

Inspired by this theory, a considerable amount of research has taken place in recent years into the forms of adult-child interaction that facilitate children's cognitive and linguistic development (e.g. Rogoff, 1990, 1992; Newman et al., 1989; Wells, 1986; Wells and Chang-Wells, 1992; Wertsch et al., 1984). Vygotsky described this contingently responsive tutorial behavior as working in the learner's 'zone of proximal development'; more recently it has been variously described as 'scaffolding' (Wood et al., 1976) or 'prolepsis' (Wertsch and Stone, 1985). Whatever the term used, what is emphasized in all these accounts is the way in which the tutor (whether parent or teacher) takes the learner's attempt to perform some part of the task and appropriates it into her or his more mature version, thereby giving it a significance which it does not yet have for the learner. In so doing, the tutor both enables the learner to contribute as much as he or she is able to the performance of the task and, at the same time, to become aware of the functional relationship between the constituent actions and the goal of the task as a whole. From participation in such shared task performances, the learner in turn appropriates the tutor's version and, having internalized it, is able eventually to perform it on his or her own. In this way, knowledge, both substantive and procedural, that is first encountered and mastered in social interaction

becomes an intellectual 'tool-kit' for thinking and problem-solving carried out by the individual alone.

Thus far, I have concentrated on learning as the remembering of the past through the taking over of the achievements of previous generations. But, as the metaphors of 'scaffolding' and 'prolepsis' make clear, this theory also involves a kind of remembering of the future as the teacher, based on his or her own past experience, projects a more complete version of a task than the learner is currently able to achieve and assists and guides the learner's performance in such a way as to bring that future about. And, indeed, on a larger time-scale, education can be seen as a form of apprenticeship, as more mature members of a culture - parents, teachers and educational policy-makers - drawing on their interpretations of their own remembered past experiences, project expectations about the future lives of the children in their care, and create opportunities for them to appropriate the cultural resources of knowledge and skills that they themselves have found important.

However, to place the emphasis almost exclusively on reconstructing the past for an imagined future has serious limitations. First, there is increasing likelihood that the future today's students actually encounter will be very different from that which we imagine; by equipping them only with the resources of the past, therefore, we will render them less able to solve the problems, unforeseen by us, with which they will have to cope. Equally important, if we emphasize tradition and authority at the expense of originality and creativity, we are failing to do justice to the transformative nature of learning and the possibility that this implies for change and improvement, both for the individual and for society.

Two further points must therefore be added to provide a more balanced account. First, it must be emphasized that internalization does not imply a simple copying from the outside in. In all cases, in taking over, or appropriating, a cultural artifact or practice, the learner necessarily constructs a new internal version which builds upon and is shaped by what he or she can already do and understand. At the same time, in the process of internalization, the learner also 'grows into' the organizing cognitive structures associated with the artifact or practice; this results in a modification of the individual's own cognitive organization and thus changes the way in which he or she perceives, interprets and organizes the world (Nikolopoulou, 1992; Rogoff, 1992). In other words, the outcome of the process of internalization is a transformation of the way in which an individual participates in a social practice, such that he or she is able to engage more effectively in the relevant activity.

Secondly, it is important to recognize that all action is creative, in the sense that each occasion of interaction with the social and material world is different from all previous occasions and demands a response which is unique to the particularities of the present moment. It may also be creative in the further sense that the solutions constructed for the problems encountered often go beyond previous achievements to create new artifacts which, in turn, have the potential to enhance the cultural resources to be used in solving future problems. Thus, just as the learner is transformed by appropriating the problem-solving resources inherited from the past, so can present problems be transformed by the new insights that learners are able to bring to bear on them.

If, therefore, we are to make good use of the insights to be derived from sociocultural theory to enhance our understanding of the goals and means of education, a concern with cultural reproduction and continuity needs to be complemented by an equal concern with cultural renewal and the encouragement of the creativity that makes this possible.

The remainder of this paper explores what these ideas might look like in practice, through a collaborative investigation undertaken by both authors into the learning and teaching that took place in one unit of work in science, the study of time which was referred to in the introduction. In fact, because of the limits of space, we shall focus on a single event - the discussion which occurred at the end of the unit, in which the teacher and children reviewed the work they had done in the preceding weeks. But first we must provide some context by saying a little about the participants in the discussion and about their classroom environment.

The School and Classroom Context for the Investigation

The school in which this investigation took place is situated in an inner-city area in Toronto. Because of its location, close to China Town and also to a number of large corporate office buildings and hospitals, the students come from a wide variety of backgrounds. Some are the children of relatively recent immigrants, who work in service jobs nearby; others are the children of doctors, lawyers, and other professionals, who have chosen the school because of its reputation and because of the day-care facilities that it provides. It should also be noted that this school is one of the few that offers heritage language instruction, in Chinese and in Spanish, as part of its regular programme; in the last few years, it has also included a Black Studies programme as part of its curriculum.

The make-up of the combined Grade Three and Grade Four class is fairly typical of the school as a whole. Children of Caucasian descent, for whom English is their first language, are in a minority, although most of those who are bilingual in English and another language have been resident in Canada since birth, or at least since they began to attend school. However, there are several who have arrived in the last year or two, who are still receiving special help in learning English as a second language. The class also contains several children who are withdrawn for additional help in literacy or with other special needs.

Although the class includes children from two grades whose current levels of attainment span a very wide range, the teacher tries to create a single community, in which each child is challenged to address the topic being studied at a level appropriate to her or his ability. For much of the time children work in groups, sometimes self-selected and sometimes chosen by the teacher. In all cases, the groups are encouraged to develop their own ways of working cooperatively, but with the requirement that each child play a part in achieving the goal that is jointly negotiated. On the present occasion, as an experiment, the teacher has decided to divide the class, with one half engaging in a unit on forensic science and the other half making a study of time.

Since this study took place in January and February, the children had already had some experience of engaging in sustained inquiry. In the previous term, they had done work in science on sound and on light and colour, and in social studies they had carried out library-based research on a Canadian province or a foreign country. Concurrently with the work on time, they were also studying endangered spaces and species. Evidence of the resources they had used and of the meanings they had made with them were to be seen on shelves and tables in all parts of the classroom and displayed on bulletin boards around the walls and in the adjoining corridor. From these same sources it was evident that, wherever possible, connections were also made between these topics of inquiry and the children's work in literature, art and drama. The study of time should be seen, therefore, against the background of a curriculum that was both integrated and challenging.

Co-Constructing the Meaning of Time

The discussion which is the focus of this paper occurred at the end of the unit and served as an occasion for the children and their teacher to make connections between the various activities in which they had engaged and the artifacts of various kinds that had mediated both their practical activity and the sense they had made of what they were doing. It started with the teacher gathering the children on the rug and inviting them to think about what they had learned during the preceding five weeks. Almost all the topics that were considered in the following forty minutes were generated from this initial invitation. They are summarized in the table presented below. The duration of each topic, in number of exchanges, is shown in parentheses in the final column.

	Topic	Initiator
T.1	Introduction: personal responses	Teacher (3)
T.2	Accuracy: need for standard measurement - comparing various methods used by groups	Auritro (10)
T.3	'Processes of science': fair test, variables - reviewing experiments on pendulums	Bianca (20)
T.4	Checking knowledge of units of time	Tema (16)
T.5	Previous work with pendulums - personal recollection	Tema (4)
T.6	Sources of power for clocks and timers - students' personal experiences	Bianca (4)
T.7	Basis for units of time in earth's movement - demonstration using various artifacts	Teacher (13)
T.8	Time differences between time zones - exploring personal anecdotes, using globe	Bianca (40)

Table 1. An Overview of the Review Discussion

Set out like this, the discussion can be seen to have had an impressive agenda, and one that very few teachers would consider it possible to treat in any depth with eight- and nine-year-olds. What was it, then, that enabled this group of children to remain interested and involved from beginning to end of this long and challenging discussion?

The first part of the explanation, we believe, is to be found in the rich variety of practical work that the children had engaged in, from which they had acquired first-hand knowledge about several of the topics that were raised. Through the activities of attempting to invent a method of measuring time, of experimenting with pendulums, and of constructing either a 'water-clock' or a 'rolling-ball-clock', they had experienced, in practice, what it is to 'do science'. They had also found themselves faced with problems that they had attempted to solve in a (relatively) principled and systematic manner. Personal experiences from outside the classroom provided a further source of information on which they could draw.

However, that is to tell only part of the story. As Driver (1983) argues, on the basis of observation of many classrooms in which children engage in practical activities in science, 'hands-on' activities do not lead to the development of an understanding of scientific

principles unless they are accompanied by 'minds-on' activities as well. In this unit, numerous instances of such sense-making occurred in the conferences that took place while the activities were being planned and in progress, and in the class discussions that occurred after each one to underline the significance of what had been done. Unfortunately, limitations of space make it impossible to do more here than hint at the richness of these continuing discussions. Mention must also be made of the various books that the teacher had assembled and which the children had been encouraged to consult for specific purposes and to browse through more generally. Equally important were the references that had been made in passing to the connections between their science investigations and the work they were doing in mathematics.

This review discussion was not an isolated event, therefore, but a part of this teacher's overall approach to the learning and teaching of science in her classroom and, indeed, to learning and teaching in all areas of the curriculum. As she explained, there are three aspects of doing science that she wishes the children to gain from the work that they do in each unit: the concepts appropriate to the topic, the processes of observation and experimentation and of making sense of the results, and the language for talking, reading and writing about the topics that they study. One of the overall purposes of this discussion, then, was to continue to weave connections between all three.

However, an equally important aim was to bring together the meanings that individual children had been making, both alone and in their separate groups, and to construct a shared understanding of what had been done and found. By bringing her own more systematic knowledge of the various topics associated with the theme of time to the co-constructive process, the teacher also wanted the children to have an opportunity to take over some of the ways of talking and thinking about these matters that are practised in the wider culture.

What we wish to explore, then, is the way in which these various aims were achieved in the moment-by-moment unfolding of this particular discussion. Furthermore, since discourse is itself a cultural artifact which learners have to appropriate through participation in actual occasions of use, a close examination of selected episodes from this particular discourse should enable us to gain a better understanding of how this process takes place. There are, of course, many approaches that can be adopted in the study of classroom discourse. On this occasion, however, we intend to focus on the role of teacher questions and on the follow-up moves in which, in various ways, the teacher extends and modifies the student contributions that are made in response to the opening questions. By so doing, we hope to show how this particular pattern of classroom discourse makes possible the co-constructive and transformative knowledge-building that was described in the introductory section of this paper.

The Need for a Standard Method of Measuring Time

The teacher opens the discussion with a very general question: 'What have you learned about time?' Tema, Emily and Jamilla obviously hear the question as a request to tell about what they have personally learned, and each contributes an interesting idea.[1]

1 Te: It's not just everything is the same thing . some
people might want to set their clocks faster or

[1]In this and the following transcripts, . = 1 second of pause; < > enclose segments where the transcription is uncertain; * = a word that was inaudible; underlining indicates segments that were spoken simultaneously.

slower or right on time

2 T: Emily

3 E: Time does not have to be telled by clocks and watches we can- we also * it can also have different sort of timers

4 T: OK, we learned about different . types . of timers (writing on board) . clocks or even watches, right? And I think what Tema said I would rephrase it as time is a form of measurement, right? (writing) a . form . of . measurement, right? Just as distance is a form of measurement . using- What else did you learn about time? . anything else? Jamilla

5 J: We learned that it um- you don't necessarily have the um- the coo- the watches like um the , minute hand, the hour hand, the second hand, you can also- you can also use water and <things like that> construct watches and um . construct clocks and it doesn't have to be um um someone- someone special makes them to be *

6 T: Uh-hmm, right (accepting) So a timing device like a clock or watch may not have the minute or hour hand, you can use the water . to represent the- the minute hand for example . or use something else to represent it Yes, what else did we study in the whole unit of time?

7 A: Counting isn't always accurate

8 T: Counting is not accurate, so there are certain pa- ways of . timing that some are more accurate and some are less accurate, for example like counting What is more accurate than counting?

9 Bi: Using the stop-watch

10 T: Using stop-watches What about the things you made? Of the- of the various things you've made what are some of the tim- timing devices you all made?

As the teacher observed, these answers are not untypical of children, or even of adults, who lack experience of engaging in metacognitive talk. In these circumstances, they tend to provide answers which are at the 'local and specific level'. As is apparent here, an invitation to reflect does not in itself enable reflection. More has to be done. In fact, as is suggested by the research on adult-child interaction (Bruner, 1983; Cross, 1977; Wells, 1986) the follow-up to a child's contribution plays a crucial role in the development of the conversation and one that makes a qualitative difference to what the child learns from the interaction as a whole. Here, in the teacher's follow-up moves in turns 4 and 6, it is evident that, as she echoes back what the children have said, she is doing three things. First, she provides an opportunity for the children to discover how their contributions have been understood and gives them a chance to make a repair if this is needed, as in 21-27. Second, whilst accepting the child's idea, she introduces an alternative way of articulating the response, thereby bringing it closer to the register conventionally used in the wider culture for

"talking science" (Lemke 1990). Third, and perhaps most important from the metacognitive perspective, she 'steps up' the children's responses to a level of talking about their personal experiences in a way that reflects a principled understanding of the topic rather than a simple telling of what they have personally learned. In other words, she is encouraging talk which requires a transformation of their personal knowledge rather than merely knowledge telling (Bereiter and Scardamalia, 1985).

In such sequences, the teacher uses her follow-up moves to model this complex but powerful thinking skill; that is to say she takes the child's contribution and, in her response to it, demonstrates how one can extrapolate from a range of specific experiences a principle which applies to those past experiences and possibly to similar future ones as well. An obvious example of this occurs in 4, where Tema's observation is utilised to form the basis for the introduction of the scientific 'thematic formation' (Lemke, 1990) 'x is a form of y'.

In the next sequence, Auritro, the fourth child to offer a personal response to the original question not only picks up on the teacher's intervening amplification of time as a form of measurement, but extends it by tacitly juxtaposing standard and non-standard methods of measurement. Counting belongs to the latter class, which "isn't always accurate" (7). Comparing Auritro's contribution to those of the preceding three children, it is clear that he is expressing an idea that has wider application and one which evidences an ability to extrapolate and articulate a principled understanding from particular physical experiences. To provide a bedrock of such experiences is, in fact, one of the teacher's priorities, as she believes that it is a necessary basis for engaging the children in talk which has the potential for knowledge transformation. In Auritro's case, he and a few other children had chosen to investigate the use of non-standard methods of measuring time, such as counting, clapping, and pouring an agreed amount of water out of a pop bottle, to measure the duration of activities such as walking from one end of the hallway to the other. In so doing, they had confronted the issue of these methods' reliability.

In her follow-up to Auritro's introduction of the topic of accuracy of measurement, the teacher makes explicit Auritro's tacit comparison by reposing it in the form of a question: "what is more accurate than counting?" (8). This question enables those children who have investigated time by using standard measurements, or those who constructed devices such as a salt-timer, to bring in their expertise. Thus, the topic is extended both in 'depth and breadth', as the teacher put it, and the children are provoked to think beyond the local level or the single case as they draw upon their collective experiences to arrive at understandings which will have wider and future application.

Following the request for specific examples (10), the next 20 turns are spent in recalling the various devices that different children had experimented with. Then, in 31, the teacher poses a question which is in some ways the obverse of the one asked earlier: 'Of all that you have done ... which are the ones that are the least accurate as a kind of . timing device?'. Her intention here is to invite the children to go beyond the devices themselves to a consideration of their relative accuracy. Then, in the following sequence, as she follows up their suggestions with a request for a justification (33), a new issue is brought into the discussion.

33 T: Counting or stamping your feet and using your heart-beat or walking round the room . that is the least accurate Why? Why is it least accurate?

34 Bi: If you <use> your heart-beat sometimes your heart-beat gets faster, like fai- um- like you've- like you've been- you've got um so many- like a lot of energy and

then <you're trained> to get your heart-beat and then because you've got a lot of energy you feel like running around, and then you start running around- your heart-beat's going to get faster <so it changes>

35 T: And I think er Bianca is bringing things to another part of this science unit <that you have learned about> . the processes of science (writing on board) .

Once again, it is a child's contribution which provides the entry to the new topic. For although, in itself, Bianca's answer is largely anecdotal in intention, the teacher recognizes in it an opportunity to bring into the discussion a fundamental principle to be observed in carrying out experiments, and one that the children have encountered in several of the earlier activities. In her follow-up move, she makes this connection (attributing it to Bianca) and announces this new topic, writing it on the board to underline its importance, 'the processes of science'. Then, following the lead provided by Bianca's reference to the variability of the heart-beat as a measure, she reminds the children of how they have talked about the need to control the variables in an experiment and, in 40, she poses the question: 'Why must we control our variables?'.

The first answer she receives shows that Tema has at least a partial understanding of what is at issue and so, to signal this, the teacher repeats the key word 'accurate' in the follow-up move. However, since this is not a fully adequate answer, she asks a probe question to elicit an alternative within the frame that Tema and she have jointly provided: 'if we don't control our variables, x is not accurate'. This is obviously a difficult question for eight-year-olds to answer in that form. However, Bianca finds an alternative, but appropriate, solution by repeating a phrase that has been used on a number of previous occasions: 'It's not a fair test' (43).

40 T: OK . why must we control our variables?

41 Te: Because if we don't, the time won't be accurate and so you won't get the correct timing

42 T: Not so much the time is not accurate, what is not accurate?

43 Bi: It's not a fair test

The Principle of 'A Fair Test'

The problem of how to make sure that their experiments were 'fair tests' had been introduced in the very first activity of the unit. Some had chosen to try to construct a salt timer that would measure exactly one minute. Emily, Veronica and Lily had chosen to invent a way of measuring how long it took to empty a bottle of water. In a conference with their teacher when they had gathered their materials together, the teacher had presented them with two problems to solve: the first was to invent a method of measuring how long the emptying took, and the second was 'to make sure your test is fair'. To help them understand what was meant by a fair test, she had discussed a number of possible variables with them:

T: The meaning of 'fair test' is if you empty a bottle- say if you fill the bottle half . and Veronica fills her bottle full . would it be a fair test?

V: No

E: No . you have to- if I filled my bottle half and to make that a fair test she would fill her bottle half

T: That's right . and what about Lily's bottle?

E: She would fill her bottle half

T: half
So all your three bottles must have the same amount of water
Now how do you ensure the same amount of water?

E: Well .

T: Do you just estimate?

E,V: No

A few minutes later, the children returned to their corner of the classroom and carried out the first trial, clapping plastic cups together to mark the beat and counting the number of claps that were made before the bottle was completely emptied. In the first trial, Lily's bottle was only half full, so the trial was aborted and they returned to the bucket to fill all their identical Fivealive bottles 'to the brim'. Then they took it in turns to empty their bottles, with one child clapping and the third counting the number of claps. Lily, who went first, took four claps. Emily and Veronica each emptied theirs in a count of three. Emily, who has assumed the role of group leader, pauses for a moment's reflection:

E: I know, me and Veronica are tied
Do you know why you were slow? (to L)

When Lily does not answer, she puts the question again in a different form:

E: What we did- . what we did was we . did a method by timing
Now, d'you guys think it was a fair match?

V: Yeh

E: Do you? (doubtfully)

V: Cos we each used the same . <thing>

At this point, Emily goes to fetch their science logs so that they can record their results. But the problem of the discrepant results is obviously still bothering her for, when they have finished writing, she returns to it again.

E: I want to ask you some questions before we do something
Why do you think it was a fair match?

V: Cos the bottles were filled to the exact same amount .
because exactly the same *

E: Yeh, like we counted EXACTLY . *

V: Yeh like I ****-

E: Now . why d'you think . she lost? (referring to L)
Why?

V: Cos she was .

E: Probably she poured it- probably she poured it slow

V: Like she goes like this (demonstrating) and then she-

While Veronica is speaking, the teacher joins the group to find out how they are getting on. Emily and Veronica describe what they have been doing, ending with a summary of their recent conversation. The teacher's follow-up question prompts Emily into a statement that recognizes that, for the test to be fair, the angle of pouring must also be controlled.

T: OK, so you- so that is a good observation- you observed . that Lily's count . was more . than both of you . and you figure that it's because of the way she poured it
Now, how can you make sure . that it's a fair test between all three of you?

E: Well . a fair test- well I don't really think it's fair now because . it was fair we put it the same size of the cup by the measuring cup, but I don't think it was fair because we poured it- we turned it right over . and Lily just poured it like this, kind of
So I don't think it was fair .(T: Uh-huh) I that- I think that's why she um- . was slow

Writing in her log book later, Emily made the following entry:

Test 1
It wasn't a fair match because Lily tilted her bottle sideways. Our method was claping.

and for the activity as a whole:

What I learn
I learned that if the bottle has a small mouth the water will come out slower than a wide mouth bottle.

From the episode that we have just summarized, it seems clear that Emily, at least, has developed some understanding of the principle of a fair test and, as leader of the group, she has also drawn the other two girls into using this principle in a consideration of their results. However, it is worth noting that, in her original posing of the question to her friends, she uses the expression 'a fair match'. In taking over the teacher's concept, it seems, she has assimilated it to her own concept of a competition and, as a result, she has recast the results of their first trial in terms of Lily having 'lost'.

There are various ways in which this might be viewed: as an indication of a discrepancy between Emily's understanding of the principle and the more conventional interpretation; as evidence of the connections she has made between a new idea and a domain which is both familiar and significant to her; or as a novel application of the principle of a fair test. All of these would probably be valid interpretations. But what seems most important to us about this episode is the clear evidence it provides of the way in which the children are actively making sense of what they observed in the trial, using the concept of 'a fair test' as a tool to help them do so, and gaining a greater understanding in the process.

In fact, in the next activity, in which the children had experimented to discover which variables affected a pendulum's period of swing, there was a further opportunity to appreciate the importance of changing only one variable at a time in order to ensure that the test was fair. And it is to a collaborative reconstruction of the different groups' experiences with pendulums that the teacher now turns in the review discussion.

44 T: Remember when you did the pendulum, when one group did the bob . changing the weight of the bob, one group changing the type of bob, one group changing the

release height . and all of us did changing the length . that- what- when you want to change the release height what was constant? What was the variable we held constant?

Emily's group, which on this occasion also included Bianca and Jamilla, had tested the effect of changing the weight of the bob. Over a period of some thirty minutes, they had systematically added one washer at a time to their string pendulum and timed the number of complete swings in thirty seconds. The following extract captures something of the quality of their engagement in the task.

Lily has just added the fourth washer and Emily, who is responsible for timing each trial with the stopwatch, prepares to start.

E: OK, ready?

B: No ..
We've got to measure it to forty-four

[B takes the tape-measure and, while V holds the pendulum horizontally, she measures its length]

V: Forty-four?

B: Yes

E: On your marks .. get set, go!

ALL: One, two, three .... (continue counting)
[V sways from side to side with the pendulum, making as if to push it on each swing]
nineteen, twenty, twenty-<u>one</u>

E: <u>Stop!</u>

B,V: Twenty-one (laughing)

B: Look, twenty-two, twenty-two, twenty-one, twenty-one
(reading the results from the chart on which J is entering them after each trial)

E: Five (instructing them to make the bob up to 5 washers)

While Lily is adding the next washer, Emily has nothing to do and she idly swings the stopwatch by its carrying strap. As she is watching it swing, she suddenly sees the significance of what she is doing and announces: 'I've got a pendulum'. Jamilla immediately picks this up and starts to swing the kiss-curl on her forehead, announcing that she too has a pendulum. She is followed by Bianca, who swings her pony-tail as a pendulum, and finally by Veronica who, not to be outdone, shakes her whole head to make her loose hair swing as a pendulum. They all laugh with pleasure at the discovery of this extension of their understanding of what may function as a pendulum.

By now, the extra washer has been added and Emily is keen to proceed. But there is a problem. The knot is not secure.

V: No wait

L: Uh-oh . that not way to tie it on

V: I started to hold them and they ***

B: I'm wonderful at tying knots, I love them
I mean I like tying them

While Bianca is retying the knot, the teacher approaches to check on how they are progressing.

T: What did you get, guys?

B: We got a pattern of twenty-two, twenty-
two, twenty-one, twenty-one

J: -two, twenty-one, twenty-one (chiming in)

B: We want to see what it's going to be this time

E: I predict the more washers there, the less * swing

B: I think this time maybe we'll get something like
nineteen, eighteem or twenty . something like that

J: Maybe

B: Maybe

E: I predict twenty dead . bet you have twenty

As the teacher walks away, they prepare to start the next trial. But first Bianca insists that they must measure the string to make sure that it is still the right length. As she does so, she notices that, with all the tying and untying, the string is fraying.

B: Cos it's actually .. it's actually the string that's
breaking .see

V: Yeah, it's the string

B: So what we have to do is the string's probably getting
shorter by the minute

?: I don't get it

B: Because it's breaking, you know these things are
getting heavy on the string and if they're all
unpleating . next thing you know it'll be tearing off

Finally, however, the knot is firmly tied, the length of the pendulum checked, and the trial completed. The result is as before: twenty-one swings. After considerable further discussion, they decide that changing the weight of the bob does not systematically affect the period of swing. This is captured in the following extract from Emily's journal entry for this activity:

My Observation
I learned that adding more washers make no difference.
Not even the count of swings.
I thought it would put more wight on the string so it
will go slower each time.

When it is their turn to report, then, there is a wealth of shared experience within the group on which to draw. However, for Veronica, who is chosen to speak for the group, it is still a difficult task to express what she knows in a form that is explicit enough for others to understand. Nevertheless, with prompting questions from the teacher and contributions

from other members of the group, a satisfactory account is constructed. Finally, after the last group has reported in similar vein, the teacher invites the whole class to join with her in drawing a conclusion about the principle's more general applicability:

72 T: So that is an example of what we mean by 'a fair test' ... it's very important in science Those are some of the science processes you have to think about . OK?

'What Time is it in Scotland?'

At this point, we want to move on more rapidly to an episode that occurred some ten minutes later. In the interim, the group had reviewed the designing and making of water timers and rolling ball timers as further instances of the 'science processes you have to think about'. Then the teacher had reopened the more general discussion of what they had learned about time and, on the basis of Tema's contribution,

91 Te: I learned that time may not only be in seconds , you may . see it as a minute, a second- and a second is made up of . quite a few fast counts

she had spent a few minutes in checking that the children knew the constituency relations between seconds, minutes, hours, days, weeks, months and years (92-129).

Next followed another opportunity for students to talk about what they had learned (130-159), which the teacher followed with an episode of more direct teaching about the basis for the different units of time in the movement of the earth on its axis, and in its orbit around the sun. This latter topic was also developed dialogically, but interspersed with longer turns by the teacher, in which she accompanied her explanation with demonstration, using two of the balls from the rolling ball timer to represent the earth and the sun.

The episode to be examined next followed directly from the one just described, and was originated by Bianca. In a pause that occurred while two children were going to fetch the globe, she raised her hand to indicate that she had a contribution to make.

204 T: Yes . while . somebody's doing it (= fetching the globe), Bianca you have a question?

205 B: Well, um, you know last night I was going to bed something like quarter to ten- I can't exactly remember but um my sister said that um- I asked her um 'Guess how lo- guess what time it is in Scotland' (Bianca has recently arrived in Toronto from Scotland) and she goes 'I think it's um about ten o'clock' and I go 'But it's only ten o'clock here it can't be ten o'clock over there' (T: Mm) . so I counted back five for the time difference and I said 'It's actually four thirty um in the afternoon and they're just about to have their cookies

206 T: Very good Now Bianca's bringing up another point

Given the point at which she makes this contribution, it is likely that Bianca has already made the connection between the time differences between different countries and the rotation of the earth in relation to the sun. However, because other children may not have followed this implicit connection, the teacher makes it explicit by relating the anecdote to her previous explanation and by once again demonstrating the two movements of the earth, this time using the globe to represent the earth and Angeline, who is sitting at one end of

the semi-circle of children, to represent the sun. Then, against this general background, she goes on to consider Bianca's example in detail, correcting, in passing, the error that Bianca had made in carrying out the rather difficult operations involved in calculating the time difference between the two countries.

Although the teacher had not embarked on the discussion with a preplanned agenda of her own, the topic of time zones would obviously have been a candidate item for inclusion on such a list. When Bianca presents an opportunity to bring it into the discussion, therefore, the teacher is pleased to take it. Once again, there has arisen what the teacher later described as 'a teachable moment'. This is made particularly clear in her focusing move, 'Now, Bianca's bringing up another point' (206), in which she deftly accomplishes two purposes, first, that of authorizing the relevance of Bianca's anecdote and, secondly, that of signalling that the topic is one of general importance, that merits further discussion.

In fact, this topic is pursued for the remainder of the lesson, as it is one that is of personal significance to many of the children. Drawing on anecdotes similar to Bianca's, contributed by children with relatives in Hong Kong, the Phillipines and other countries, the teacher is able to help the children to attach real-life significance to the concept of time zones, and the differences in time between them, which might therwise have been too abstract for them to grasp. One of these anecdotes, in particular, is worth quoting in full.

The class contains quite a number of Chinese-Canadian children, and Emily, whose family comes from Hong Kong, has just been recounting a conversation with her father about the time difference between Hong Kong and Toronto:

258 E: ... say it was nine o'clock and I asked Dad 'What's it like in Hong Kong now?' and he said 'It's- it's the same time but it's the morning, nine o'clock in the morning'

As the teacher recaps and makes the connection to Bianca's example, Lily, another Chinese-Canadian girl, raises her hand. As the teacher immediately recognizes, this is an important moment. Lily has only been living in Canada for just over a year, and is usually very reticent about speaking in front of the whole class. On this occasion, however, she clearly feels her story is sufficiently important for her to request an opportunity to tell it.

266 T: ... that's why your Dad says Hong Kong to here is a twelve hour difference, that's exactly . half way round for time whereas . Scotland to here is five hours difference Yes, Lily

267 L: When I was in China . my Mum always called me at the night and er- and I- I don't like- I don't er- I don't want to wake up and my- my Grandmother say 'You have to wake up, your mother on- in the phone' . so I have to listen to him

268 T: That's right . she says- Lily says that when she was in China . where's China? you show me (to L)

[Lily points to the position of China on the globe]

269 A: Er you just-

270 T: There, China's over here . (demonstrating) and her Mum was in . <u>Canada</u>

271 L: <u>Canada</u>

272 T: - her Mum called at say two o'clock in the afternoon, say

now, cos the sun is there two o'clock I would say it's roughly here . is she still asleep?

273 Ch: Yeh

274 Bi: Two in the morning, **

275 T: Now, it's really not as much as Hong Kong, * slightly less, but she's still asleep . so that's why she was telling us her grandmother said 'Your mum is on the phone, get up! Your Mum is calling you', which means phoning for you, and she says 'Why does she phone me at night?'
But is it night for your Mum?

276 L: No

277 Ch: No

278 T: No, it's daytime . and say if Lily comes over- the earth moves here and it's daytime (i.e. in China) and Lily calls her Mum . Lily phones her Mum, would her Mum be awake or asleep?

279 Ch: (laugh) Asleep

280 T: See now why? do you see it now with the globe and the sun

281 Ch: Yes

As in learning their first language, what prompts children to take risks in using the linguistic resources they are learning in a second language is so often the combination of having something they feel it is important to say and an audience who will be interested to hear it. And this is what happens here. As with other children's contributions, the teacher picks up Lily's anecdote and retells it to give it added effect, using it at the same time as a particular case of the more general principle that is under discussion. Whilst illustrating the rich resource for developing understanding that is to be found in multicultural classrooms such as this, this episode also exemplifies very clearly just what is meant by the co-construction of meaning.

Learning from the Past; Learning for the Future

In the introductory section of this paper, a way of thinking about education was outlined in which teaching was characterized as the provision of opportunities for learners to appropriate the achievements of past generations - as these are embodied in cultural tools and their associated practices - and to transform them into a personal resource for individual thinking and problem-solving now and in the future. This discussion, we wish to suggest, is an excellent exemplification of this process in action. And, in order to justify this claim, we should like to revisit the section of the discussion concerned with 'the processes of science', in order to consider it from this point of view.

The principle of 'a fair test' is just such an intellectual artifact - or tool - and one which is of central importance for the way in which scientific understanding is advanced in our culture. Indeed, it is so central that it is easy to ignore its artifactual nature. Yet this principle, which is taken for granted as necessary in any experimental attempt to understand relationships of cause and effect in the material world, was developed in the course of practical activity by our predecessors over many generations in the past. And

that it is an artifact that has to be learned in action was made very clear in the course of the activities in which the children engaged and in the accompanying discourse.

We have already seen how Emily and her friends grappled with the problem as they reflected on the probable reason for Lily 'losing the match'. Now we want to consider the experience of Auritro and his group as they tested the effect of changing the type of bob on their pendulum and in the subsequent discussions.

In the class discussion which was held at the end of the experimental work on pendulums, it was finally agreed that it was only changing the length of the pendulum that changed its rate of swing, and a rhyming slogan was coined to make this finding memorable: 'The longer the string, the slower the swing'. However, earlier in this session, when the groups described what they had done and reported their results, Auritro's group had reported results that were anything but conclusive. The problem, it transpired, was that, in changing the type of bob, they had been unsuccessful in keeping the length of the string constant. Now, compared with the results obtained by the other groups, who had been more successful in changing only one variable, theirs were impossible to interpret. Asked to comment on them, he described them as 'pretty wacky', and when they were displayed using another artifact - that of graphing - it was clear that, as he put it, they were 'all over the board'. This evaluation is confirmed by the entry he had already written in his log:

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Topic:          Swing time

Question:  Will the type of bob change the swings?

Well it was confewsing for us wich is Me, Kelvin, Benjamin
and Tsz-yeung. We made another pendeleum and testing lots of
things.  First we checked the lengths. The first and second
time the lengths where different.  The last time it was same
but counts were different. Heres the chart
We used Nails, washers, screws and a cup
Nail    =  24  going back and fourth
Washer  =  23           /
Screw   =  21           /
Cup     =  23           /
                going back and fourth counts as one swing.

I think what we had odserved was right but was wrong.  We had
done something wrong with Nail and screw.  I dont how that
happend but it did.  I think our counting was wrong.
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However, in the second section of the present review discussion, in which the experiment with pendulums was reviewed from the perspective of 'the processes of science', these difficulties were no longer alluded to. Instead, it was the principle of a fair test that was emphasized, with its operationalization in the controlling of variables. Through the successive sequences of discourse, the experiences of the separate groups were jointly reconstructed as instances of carrying out a fair test. As the teacher explained afterwards, since the children now knew that only length affected the rate, what in her view was important to emphasize in the discussion was not whether they had succeeded in holding all but the experimental variable constant, but the fact that they had attempted to do so and understood why this was important.

Another way of looking at this episode is as a particularly clear example of the general principle of cultural learning, discussed earlier, in which the learner is enabled to take over the culturally accepted practice by being taught to use an artifact in which the outcome of past achievement is encoded. Here it is the meaning of a fair test that the teacher wishes

the students to take from their practical work and the accompanying discussions. So, by appropriating what actually happened in Auritro's group and reinterpreting it in terms of what would have happened if they had followed the cultural practice associated with the use of this artifact, the teacher is helping the children to take over the practice, together with the understanding that it embodies, as a tool that they can use in all future scientific experiments.

To construct culturally appropriate 'common knowledge' that is personally relevant for all members of the classroom community, as Edwards and Mercer (1987) point out, requires a context of shared experience and a collaborative mode of discourse. So far, in reviewing this discussion, we have examined the shared experiences from which it arose. Now, let us focus on the discourse, as the means by which the goal is achieved.

Teachers' Questions in the Co-construction of Knowledge

The first thing to note is the way in which the teacher provides opportunities for the children to contribute from their personal knowledge and experience. As Table 1 above shows, all but one of the major topics originated in a contribution from one of the children. It was as if the teacher's initial invitation to tell about what they had learned during the course of the unit was maintained as a macro-question which provided an organizing framework for the whole of the ensuing discussion. Every time there was a sense of closure with respect to the current topic, a child's hand would go up to request the right to introduce another.

However, the smooth and coherent flow of the discourse is also the result of the teacher's ability to see and exploit the potential in each of their contributions. As might be expected of children of this age, these are largely observations and anecdotes drawn from personal experience. In each case, what the teacher does is to elicit similar observations and recollections from other members of the group so that, together, their contributions are built into a shared account which she extends and reinterprets in the language that is used to talk about the related activity in the culture more generally. In this way, while encouraging and valuing the ideas and experiences that the children are keen to contribute, the teacher, as 'an authoritative representative of the educated culture' (Edwards and Mercer, 1989, p. 97), provides an opportunity for the children to take over and internalize her organizing cognitive structures and associated language so that, in the future, they will be able to deploy these resources when engaging in further activities of this kind.

With this conception of her role, the teacher's choice of the triadic dialogue mode is readily understandable. As Newman, Griffin and Cole (1989) point out, the advantage of the three-move sequence of Initiation-Response-Follow-up is that, whilst enabling the discourse to be co-constructed, it allows the teacher the option, in the third move of each sequence, to extend or modify the response she has received to her preceding question. It is in this follow-up to the child's response that she most obviously 'works in the learner's zone of proximal development' and, indeed, in reflecting on the videotape and transcript of the review discussion, it was this aspect of her role that the teacher felt to be the most important.

However, since the child's response is an attempt to meet his or her interpretation of the demands posed by the preceding question, the teacher's questions are also important. By their very nature, questions set up expectations as to what will occur in the moves which follow. Nevertheless, the control that the teacher thus exercises over the way in which the discourse proceeds need not result in the suppression of student initiative and creativity, as

Wood (in press) has charged. For it is not the asking of questions, as such, that has this constraining effect, but rather the functions of the questions that are asked.

If we look in detail at the teacher's questions in the episodes that have already been cited, it is clear that they perform a wide range of functions, including all of the following:

- inviting students to contribute personal accounts of what they have learned from the work they have done;
- requesting them to recall specific information about the activities they have carried out;
- requesting them to evaluate or suggest interpretations of information that has been offered;
- requesting them to justify or explain an interpretation or observation that has been made;
- requesting them to make a prediction, draw a conclusion or formulate a more general principle on the basis of what has already been established;
- requesting them to display their mastery of conventional knowledge, both substantive and procedural.

Only the last of these functions leaves no scope for individual initiative in deciding what or how to respond, and questions with this function accounted for less than a third of those asked over the whole of the discussion, with the majority of these occurring in relation to two topics - the relationship between the various units of time (e.g. seconds, minutes, hours, etc.) and their basis in the different movements of the earth in relation to the sun. For the most part, then, the teacher's questions were designed, not to elicit a predetermined answer nor to evaluate the 'correctness' of the students' knowledge, but rather to invite them to make a particular type of contribution to the structure of meaning that was being jointly constructed by the group as a whole.

But the teacher's questions and follow-up moves do not serve only to advance and guide the current interaction. With the responses they elicit and respond to, they also provide a potential model, on the inter-mental plane of public discourse, for the intra-mental dialogue of inner speech in which individual thinking and problem-solving is conducted. Vygotsky (1962) hypothesized a developmental progression in the learning of any aspect of cultural knowledge, from adult-assisted interpersonal interaction, through interaction with peers, to a stage when the individual is able to function autonomously under the control of the discourse structures internalized from social interaction. In various contexts throughout the unit, one could see this developmental process in action, as children tried out the language they had encountered in conversations with the teacher. The episode quoted earlier, in which Emily initiated a review of the results of the bottle-emptying task, is a particularly clear example of the intermediate stage in the hypothesized trajectory.

Conclusion

In presenting an analysis of this one discussion, we have tried to show how it can be seen as part of a continuing cultural process of appropriating the achievements of the past and transforming them into a resource for creative and innovative problem-solving in the present and future. In the episodes examined, we have seen how the experiences of the immediately preceding few weeks were collaboratively reviewed and their meaning reinterpreted in terms of principles and practices that previous generations had invented to

make sense of the phenomena in question. Although similar discussions had occurred in relation to the various activities that the children had engaged in throughout the unit, this one had particular importance in that it was used as an occasion for making connections between these individual topics in order to achieve a more integrated understanding of the theme of time.

Such opportunities to synthesize and reflect on what has been learned occur all too rarely under the pressure that many teachers feel to hurry on in order to cover the suggested curriculum. Yet they are essential if school learning is to be more than the accumulation and memorization of isolated bits of information. For if the goal of genuine understanding is to be achieved, each individual learner needs to make sense of the separate bits by relating them to each other in terms of the common knowledge which is constructed in collaborative talk about questions that he or she has investigated and which is mediated by the larger framework of culturally constructed knowledge.

But it has also been one of our aims to show how, in appropriating the artifacts from the past, children use them for their own purposes and put their own stamp upon them. In the discussion we have examined, the episode in which the basis for the different time zones is explored provides the best example of the former. For Lily, who has rarely spoken in the whole class group, the new understanding she has achieved of the personal experience of being phoned by her mother in the middle of the night is significant enough for her to break her silence with a brief story that enables her to become a fully participating member of the class. In a different vein, Emily's personal interpretation of a fair test as involving competition ('a fair match') is subsequently seen in her group's design of a dripping water clock with two sets of cups instead of one so that they can organize races between the two sets. But perhaps more significant than either of these rather specific examples is the tenor of the discussion as a whole, with its numerous examples of the children's ability to infuse the general concepts with their own personal and particular meanings and at the same time to reframe those personal meanings in more public terms that made them relevant and therefore worthy of sharing.

However, as already mentioned, there had been similar opportunities to co-construct meanings in this way in the work they had done earlier in the year. Their ability to contribute productively to the present discussion thus had its roots in previous experiences in this classroom and, to varying extents, in experiences outside the school. Such retrospective discussions thus play a crucial role in enabling the class to reconstruct a growing range of past experiences as a context for future learning. This discussion, and the unit of study which it brought to a completion, should therefore also be seen as part of a larger, spiral process, which continues throughout the year and, hopefully, through all the years of schooling.

A second theme of the paper has been the dual role of discourse in the learning and teaching of science. On the one hand, since 'doing science' is to a considerable degree a matter of participating in the various discourses by means of which the scientific community addresses the problems of current concern and creates and debates novel solutions that have the possibility of transforming and extending previous knowledge, so one of the major goals of the science curriculum must be to enable students to gain sufficient control of these specialist discourses to be able to use them in constructing their own knowledge. On the other hand, as we have seen, it is also in the ongoing discourse of the classroom that the teacher and students create the forum for co-constructing the meanings in terms of which they make their own sense of these specialist discourses and of the situations to which they apply.

The same arguments could be made for the other subjects in the school curriculum. In all areas, for students to appropriate the modes of discourse that are specific to the different discipline-based ways of doing and knowing so that they are able to take part in them and, in so doing, to reshape them to their own purposes, is one of the major goals of education. At the same time, it is in the more familiar patterns of classroom discourse with their peers and teachers that students are enabled to build bridges between these specialist discourses and those with which they are familiar from their experiences at home and in the larger community. It is therefore in providing opportunities for this apprenticeship into the discourses of the disciplines that we shall, in our view, most fully achieve the aims that are captured in the phrase 'language across the curriculum'.

Uniting both these themes is the three-part structure of Initiate - Respond - Follow-up. This is already familiar as a way of describing the manner in which much classroom discourse is organized, with the teacher asking a question about a topic that she or he wants the students to address and then commenting on the response received in order to develop its potential as a basis for further learning. On a larger scale, this same three-part structure may be seen as the fundamental organizing principle of the unit as a whole and, indeed, of education in general.

As teachers, our task is to present our students with challenges of various kinds that initiate new cycles of learning. Our hope is that, if our challenges are well-chosen, they will engage the students' interest and stimulate them to respond by making their own sense of the problem and by constructing personal solutions to it with the resources, both personal and cultural, which they have at their disposal. These responses then provide the basis for us to follow up with teaching that is tailored to their particular needs and informed by the wider cultural context. As in most discourse exchanges, it is also in this third step that the next cycle of the learning and teaching spiral has its point of departure.

This paper started with an account of just such an event, when the problem posed by the malfunctioning waterclock led to a creative solution and provided an opportunity for all of us - teachers and students - to be assisted in our zones of proximal development. We should therefore like to end with Emily's insightful conclusions about the year's work. In a discussion with Emily and her friends at the end of the year, they were asked how they, if they were responsible, would plan the work for the next year's students. This is her reply:

> We should give the children - the grade threes that came - to go through the 'Innovations' [the resource book they had used[2]] and then I would ask them questions, like what we did or what we remember, like 'What is science?' 'What did I think of it?' and I would- I think I would start them by um- giving- start with projects- not projects but making things, and then I think I would um- a few days later I would gather them on the carpet and they all share what they observed and then see they'll become like us, just writing them in our books ...
>
> But I think one thing very important is that we all discussed about it - like talked

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Notes

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[2]*Innovations in Science.* Toronto: Holt Rinehart and Winston, 1991